

SAMA PATENTS

AF 9343/EUR/031

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



Publication number:

0 665 253 A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 95101145.1

(51) Int. Cl.⁵: C08G 65/00, C09D 171/02,
C08G 65/32

(22) Date of filing: 27.01.95

(30) Priority: 31.01.94 IT MI940155

(43) Date of publication of application:
02.08.95 Bulletin 95/31(84) Designated Contracting States:
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(54) Coatings based on fluoropolyethers.

(57) Use of fluorinated polymers for the preparation of high dry formulations wherein the fluorinated polymers are based on fluoropolyethers comprising a fluorinated part R_F and optionally an hydrogenated part R_H , the bonds joining the fluorinated part to the hydrogenated one being of ether C-O simple type, the terminals T being such as to render the structure bi or polyfunctional, making thus possible the crosslinking reaction, the hydrogenated part R_H not containing groups capable of linking by means of hydrogen bonds to basic acceptors.

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The present invention relates to "high dry" formulations for preparing paints and coatings in general. It relates in particular to "high dry" compositions based on fluorinated polymers. As "high dry" we mean formulations wherein the solvent is 20% by weight at most, preferably 10% by weight. More particularly the object of the present invention relates to compositions suited for top coating, in particular in the car field, endowed with optimal capacity of adhesion to pigmented bases, high hardness, protective and antispot properties, scratch resistance, weather-proof and in particular resistant to UV radiations. Moreover the compositions must be usable in field applications, that is outside, assuring high aesthetic qualities, such as high gloss, image definition (DOI), together with the protective function and utilize a little solvent thus reducing the environmental impact. High dry formulations can be used in a range of temperatures generally from 10 °C to 50 °C.

This however depends on the crosslinking system, as well known, for instance melamines and blocked diisocyanates require higher temperatures.

The use of fluorinated polymers for preparing coatings is known. These polymers are endowed with very good chemical, thermal and UV resistance and oleo- and water repellence. Known formulations for coating, having a fluorinated basis, are for instance chlorotrifluoroethylene (CTFE) copolymers with hydrogenated vinyl ether or vinyl esters; or VDF (vinylidene fluoride) polymer or copolymers with tetrafluoroethylene and/or hexafluoropropene. The former are for instance LUMIFLON^(R) and CEFRAL^(R), the latter are commercialized for instance as KYNAR^(R) and TECNOFLON^(R).

The main drawback of these fluorinated polymers is that they are at high dilutions, even of 90% by weight of solvent. This leads to high costs for eliminating the solvents, since the solvents needed for preparing the formulations of these fluorinated polymers have a high environmental impact.

In the case of TECNOFLON^(R)-based coatings, chlorofluorocarbon solvents, which will be no longer used according to the laws of all countries, are presently used. In conclusion, these fluorinated polymers even though endowed with the indicated excellent properties, cannot be used for high dry formulations.

It is known in the art also the use of partially fluorinated copolymers, for instance perfluoropolyethers of elastomeric or filming type, crosslinkable depending on the molecular weight and on the ratio between fluorinated part and hydrogenated part.

However these products need to be used at high dilutions. Moreover weather stability is not good. Also for these products, therefore, it is not possible to prepare high dry formulations.

Coatings based on polyesters from perfluoropolyethers and coatings based on perfluoropolyethers containing acrylic groups are also known. One can see European patent applications 622353 and 622391 in the name of the Applicant. These products give good coatings and allow to use less solvent than the products of the art indicated above. However it is not possible to obtain high dry formulations from these products since they require an amount of solvent of about 50% by weight.

It is also known the use of water coatings. These formulations contain a low amount of solvent, of about 10%, whereby they could fall within high dry formulations, however they are endowed with low chemical resistance and moreover do not show the high aesthetic and mechanical properties, such as the gloss and the hardness that the high quality coatings must have.

There are known coatings belonging to the category of solvent-less, that is homogeneous bicomponent compositions without solvents or having a limited amount of solvents, applicable by means of traditional techniques and therefore endowed of minimum environmental impact. Epoxy resins can be mentioned. These resins however lead to poor coatings (coatings of inferior quality) from the aesthetic point of view. For instance the gloss of the coatings is of the order of 10-20 at 60 °C according to ISO 2813 standard. These compositions, however, do not allow to obtain reduced coating thicknesses, lower than 50 μ, as requested in the top coating.

Moreover the finishing of these products is not very good.

Object of the present invention is obtaining "high dry" formulations based on fluorinated polymers capable of giving crosslinked films having the combination of properties indicated above: very good chemical, mechanical, thermal properties and resistance to UV radiations, usable also for applications on the field, very good aesthetic and durability properties, scratch and spot resistance.

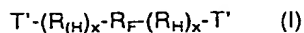
The Applicant has unexpectedly and surprisingly found that it is possible to prepare "high dry" formulations based on fluoropolyethers if functionalized fluoropolyethers, as defined hereinafter, are used.

It has been surprisingly found that the polymers based on fluoropolyethers as defined below do give "high dry" formulations since they require the addition of small amounts of solvent, of about 10% by weight and generally lower than 20% by weight.

Object of the present invention are high dry formulations of fluorinated polymers for preparing paints and coatings wherein the fluorinated polymers are based on fluoropolyethers comprising a fluorinated part R_F and optionally an hydrogenated part R_H, the bonds joining the fluorinated part to the hydrogenated one

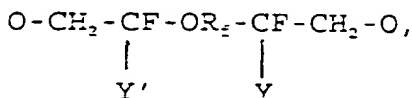
being of simple ethereal C-O type, the terminals T' being such as to render bi or polyfunctional the structure and thus making possible the crosslinking reaction, the hydrogenated part R_H not containing groups capable of linking by means of hydrogen bonds to basic acceptors.

More in detail, preferred are the fluorinated products which can be represented with the formula



wherein

R_F is



wherein R_F is a fluoropolyetheral chain, Y and Y' being same or different from each other and being F or CF₃

x is 0 or an integer from 1 to 10, preferably from 1 to 3;

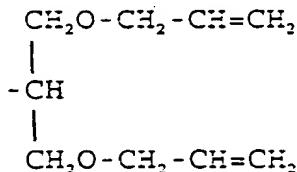
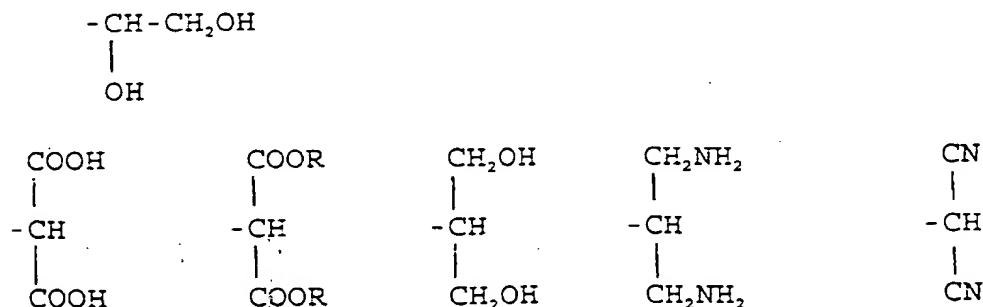
R_H is a linking bivalent radical, of linear aliphatic type -(CH₂)_m-, m being an integer from 1 to 20, or of (alkylene)cycloaliphatic type or of (alkylene)aromatic type, optionally having also heteroatoms on the ring or in chain, the number of carbon atoms being from 3 to 20 for the cycloaliphatic compounds, and from 5 to 30 for the aromatic ones; the R_H group can also be a mixture of the types indicated:

T' = -(CH₂CH₂O)_n-R_H-T, wherein n is 0 or an integer from 1 to 6, preferably from 1 to 2;

x' is 0 or an integer from 1 to 10, preferably from 1 to 3, x' can be different from x; and

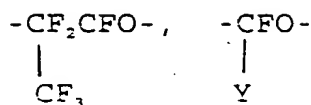
T being hydrogen or a terminal capable of rendering bi- or polyfunctional the structure such as to make it reactive towards the crosslinking agents of both ionic and radical type.

In particular terminals T are preferably of the type:



In particular the following groups must be absent from the hydrogenated part R_H: -COOH, -NH-COO-, -NH-CO-NH-, -OH; -NH₂; -NH-; CO-NH-.

The radical R_F of number average molecular weight M_n comprised, preferably, from 500 to 5000, more preferably from 700 to 1500, represents a fluoropolyetheral chain bifunctional radical, comprising as repetitive units sequences of one or more oxyfluoroalkylene units of the type -CF₂CF₂O-, -CR₄R₅CF₂CF₂O-.



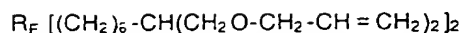
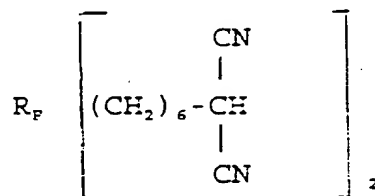
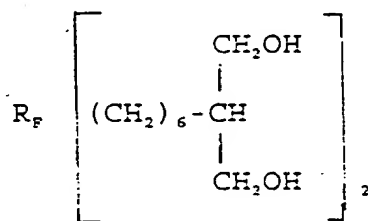
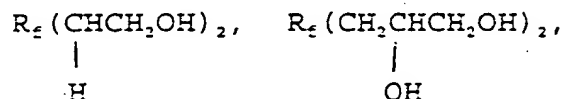
wherein R_4 and R_5 have the meaning indicated hereafter.

It was unexpectedly found that the fluorinated polymers of the present invention by addition of small amounts of solvent lead to the formation of solutions having an extremely low viscosity, generally of the order of 50-300 cPoise at room temperature.

It is even more surprising that amounts of about 2-3% by weight of solvents, selected from those generally used in the paints field are sufficient for obtaining solutions having very low viscosities such as to render them easily utilizable.

The preferred compounds of the formula I are the following:

$R_1(\text{H})_2$.



Generally utilizable solvents are those broadly used in the field of paints. They are fluorinated solvents containing hydrogen, ketones, esters of heteroalcohols, aromatics. Methyleneethylketone, methylisobutylketone, ethyl or butyl acetate, cellosolve acetate, propyleneglycolmethylether acetate, xylene are preferred. Chlorofluorocarbons not containing hydrogen are excluded as solvents.

The crosslinking agents used are the commercial ones and however the ones well known for the crosslinking of the crosslinkable functional groups. For instance the polyhydroxylated products of formula (I) are crosslinkable with melaminic resins, with weight ratios comprised between 70:30 and 90:10, preferably 80:20, of the polyhydroxylate compound to melamine; the crosslinking temperature is around 130-150 °C.

The films obtained are homogeneous and transparent, of good hardness and hydrolysis resistant.

Alternatively the polyhydroxylated polymers are crosslinkable with polyisocyanates containing isocyanurated rings, or using suitable polyisocyanic prepolymers based on isophorondiisocyanate (IPDI), toluendiisocyanate (TDI), hexamethylendiisocyanate (HMDI), etc. in the presence of metal or aminic catalysts, at room temperature or higher, using a NCO/OH ratio for instance from 1/1 to 1.5/1.

Blocked polyisocyanates obtainable from the polyisocyanates indicated above by reaction, for instance, with phenols or ketoxime can be also used. Other kinds of crosslinking are of peroxidic type by using conventional organic peroxides, for instance, di-ter-butylperoxide, lauroylperoxide, benzoylperoxide.

Other radical initiators not of peroxidic type, such as for instance AIBN (azabisisobutyronitrile) can also be used.

The excellent properties of viscosity, together with the good compatibility with the solvents of current use in the field of paints and with the various crosslinking agents of paints make the perfluoropolyethereal polymers of the present invention suitable for formulating high dry paints endowed with good optical and mechanical properties.

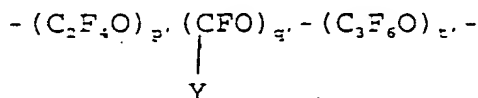
The high gloss, high image definition, high adhesion to the various types of supports, good hardness and elasticity in addition to the optimal thermal, chemical and hydrolytic resistances, can be cited.

The advantage obtainable with the compositions of the present invention consists in that very small amounts of solvent are utilized, therefore with a remarkable reduction of the environmental impact and consequently of costs for eliminating solvents and recovery thereof.

The fluorinated products of the present invention have a very good crosslinking density and then very good mechanical properties and resistance to swelling.

In particular the fluoropolyethers of R₁ type utilizable according to the present invention can be of the following types, indicating the repetitive units of the chain:

- a) $-(C_3F_5O)_m(CFXO)_n-$ wherein the unit (C_3F_5O) and $(CFXO)$ are perfluorooxyalkylene units statistically distributed along the chain; m' and n' are integers such as to give the molecular weight indicated above, and m'/n' is comprised from 5 to 40, when n' is different from 0; X is equal to F or CF₃; n' can be also 0;
- b)



wherein p' and q' are integers such that p'/q' varies from 5 to 0.3, preferably 2.7-0.5 and such that the molecular weight is the one indicated above; t' being an integer with the meaning of m', Y = F or CF₃; t' can be 0 and q'/q' + p' + t' lower or equal to 1/10 and the ratio t'/p' is from 0.2 to 6;

- c) $-CR_4R_5CF_2CF_2O-$ wherein R₄ and R₅ are same or different from each other and selected from H, Cl, the molecular weight being that indicated above, a fluorine atom of the perfluoromethylene unit can be replaced by H, Cl or perfluoroalkyl.

The indicated fluoropolyethers are obtainable with the processes well known in the art, for instance, US Patents 3,665,041, 2,242,218, 3,715,378 and European patent EP 239,123. The functionalized fluoropolyethers are obtained for instance according to EP Patents 148,482, USP 3,810,874.

The fluoropolyethers of the present invention, in particular the fluorinated polymers of formula (I) are obtained from the functionalized products, in particular from those with hydroxylic ending, according to the process indicated hereinunder.

The functionalized fluoropolyethers according to the present invention can be mixed in various ratios with bi or polyfunctional polyols having an hydrogenated basis, for instance butanediol, trimethylolpropane, pentaerithrol. The ratio in equivalents of the hydrogenated polyol to the fluorinated polymers of the invention varies from 0.1 to 5, with the proviso that the hydrogenated polyols are soluble in the formulation. In this way blends having specific properties depending on the particular type of the desired coating, are obtained. The process for preparing the functionalized perfluoropolyethers of the present invention comprises: etherification of fluoropolyether having hydroxylic ends by salification of fluoropolyether and nucleophilic reaction with alkylic or arylic dihalides or pseudohalides, obtaining a fluorinated polymer A') of formula corresponding to (I) wherein T' is replaced by X), the terminal X being susceptible of further nucleophilic attack; subsequent functionalization by nucleophilic attack of A') with compounds containing carboanions to obtain the compound of formula corresponding to (I) containing the T terminal. Then optionally transformation of the functional T groups of ester type to other groups such as alcohols, amines, acids according to well known reactions.

The fluoropolyethers having hydroxylic terminals, for instance of Z², P² and A² type (reported hereinunder) are obtainable according to known processes. For instance, Z² is obtainable by reduction of the corresponding diester according to USP 3,810,874; A² by salification of Z² and reaction with ethylene oxide. Similarly one can obtain the compounds with fluorooxyalkylene units specified above for all the products Z², P² and A² type.

In particular the process comprises:

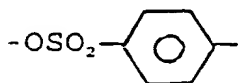
- 1° step) Direct etherification of the fluoropolyether with hydroxylic terminals, according to a pattern of nucleophilic substitution, Williamson type. In practice, the fluoropolyether (PFPE) with

hydroxylic terminals is dissolved in a solution of potassium or sodium alcoholate in the corresponding alcohol, obtaining the alcoholate of the fluoropolyether. This is slowly added to t-butanol, or other solvent (for instance dioxane), containing a large excess of alkyl or aryl dihalide or pseudohalide.

Typically in this phase 1,4-dibromobutane, 1,5-dibromopentane, 1,6-dibromohexane, 1,8-dibromooctane, 1,10-dibromodecane and other higher or lower homologous compounds with bromides or chlorides terminals, can be used as reactants. 1,4 dibromocyclohexanedimethanol, 1,4-cyclohexanedimethanol dimesylate or ditosylate, mixtures of α,α' dibromo or dichloro xylene or their pure isomers can also be used.

The reaction temperature, depending on the halide reactivity, is comprised from +30 to +90 °C and the reaction time is 1-8 hours.

The fluoropolyethers, alkylated with conversion near 100%, are isolated by precipitation in H₂O and filtration or distillation of by-products and reactants in excess. The residue or the filtrate corresponds to the general formula (A¹) (specific product of A³ type defined further on), which is the same as (I) wherein the terminal is X (instead of T). X is still a reactive replaceable terminal being of the -Br, -Cl, -OSO₂CH₃,



CH₃ type, etc.

2nd step) Functionalization. By using active methylene compounds, such as for instance ethyl or methyl malonate or ethyl or methyl 1,1,2 ethanetricarboxylate when a higher final functionality is desired, or still polyols partially protected such as glycerol formal.

The reaction of the PFPE adduct of formula A¹, obtained in step 1, with active methylene compounds occurs easily and with high yields. The adduct (A²) is added slowly to an alcoholic solution for instance of sodic or potassic malonate, at a temperature of 40-80 °C heating for 2-8 hours. The polyfunctionalized adduct I (specific product of the B² type defined hereafter), is the product of formula (I) wherein the terminal T contains COOR wherein PFPE = R_F as defined above, R_H being the alkylene residue of the halide, R being CH₂CH₃ or CH₃ of the malonate. This adduct I is isolated, with practically quantitative yields, by extraction with H₂O and distillation of the solvents and reactants in excess.

Optionally from the adduct I it can be obtained the release of other reactive functions, typically by reduction of the carboxylic esters for instance with LiAlH₄/THF or by hydrogenation, or still by extension of the carboxyls with sterically hindered dialcohols (for instance neopentylglycol), by ammonolysis and reduction to give polyamine or simply by hydrolysis to give polyacids.

The adducts of type (I) obtained by polyfunctionalization with partially protected polyols, can lead to PFPE polyols for instance by releasing the acetal by hot treatment with mineral acids.

The partially fluorinated resins so obtained having alcoholic, aminic, acid functionality, etc. can be titrated easily for determining equivalent weight and functionality, for instance with the phenylisocyanate method or with alcoholic HCl or alcoholic KOH.

The final functionality of the resin of formula (I) so obtained is in any case 2 or higher, for instance 4 and 6.

Some examples are given hereinafter only for illustrative purposes and are not intended to be limitative of the scope of the invention.

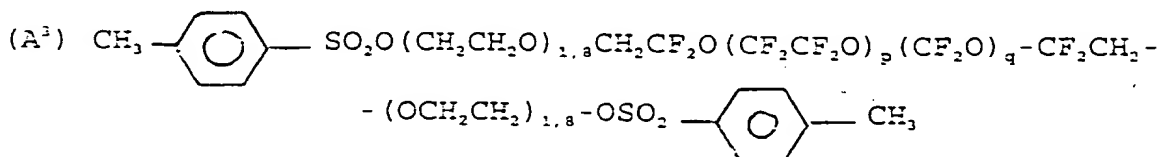
EXAMPLE 1

20 g of a perfluoropolyoxyalkylene of formula



having $p/q = 1$, and $n = 1.8$ and having a number average molecular weight M_n 1250 and functionality 1.95, are dissolved in 100 ml of a mixture 1/1 of DELIFRENE^(R) LS and toluene. 20 ml of a 50% by weight aqueous solution of potash and 200 mg of tetrabutylammonium hydrogen sulphate are added to said

solution, the whole mixture is left under vigorous mechanical stirring for 15 minutes at 20°C for obtaining the A² alcoholate. Then a solution of 6.20 g of tosylchloride is dripped in 10 ml of toluene in half an hour. The reaction is followed by TLC (thin liquid chromatography) until the tosylchloride disappears (about 1 hour), afterwards the phases are separated and the organic phase is evaporated, recovering 23 g of an oil corresponding to the following formula:



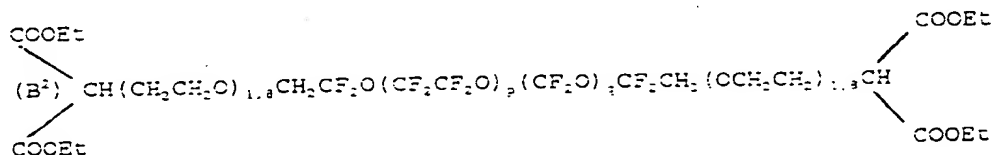
determined by NMR.

Similar results can be obtained by dissolving the fluoropolyether in pyridine at 0°C and adding the solid tosylchloride (24 hours).

Afterwards, 200 ml of anhydrous ethanol and 3.98 g of metal sodium are loaded in a 500 ml 3 necks glass flask, equipped with a reflux condenser and with nitrogen valve, a plug and a 250 ml dropping funnel.

Once the sodium is dissolved, 25.62 ml of ethyl malonate are added and after 5 minutes it is heated to 80°C. Then 100 g of fluoropolyether of formula (A³) are added from the dripper. After 4 hours the cold alcoholic solution is discharged in acid H₂O and the fluorinated oil recovered as precipitate and purified by distillation of the malonate excess.

90 g of compound of formula

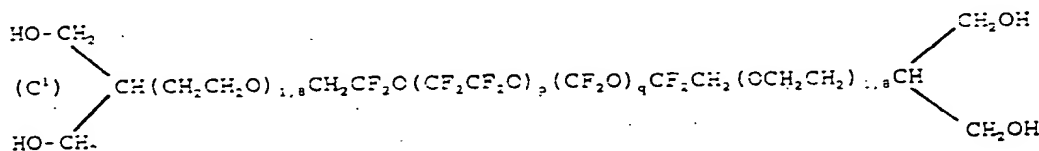


are isolated.

Into a 1 liter 3 necks flask equipped with mechanical stirring, reflux condenser, nitrogen valve and 250 ml dropping funnel, 200 ml of a 1 molar solution of LiAlH₄ in THF are loaded. A solution of 80 g of compound (B²) dissolved in 200 ml of anhydrous THF is gradually added to the LiAlH₄ solution at a temperature of 50-60°C.

After 12 hours the reaction is over and the oil is recovered by extraction of the solvents and of the by-products with acidic H₂O.

68 g of compound of formula



are recovered.

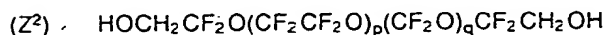
This polyol was titrated by the phenylisocyanate method and resulted to have an equivalent weight 385.

The viscosity rheological characteristics depending on temperature and solvent percentage are reported in Table 1.

The polyol (C¹) was crosslinked at 150°C, by catalysis of PTS (paratoluenesulphonic) acid, with melaminic resins type CYMEL^(R) 303 (of Cyanamid) with a weight ratio of 70:30, giving an homogeneous and transparent film. The amount of solvent required for reducing the viscosity, for preparing the formulation, comprising in this case the polyol and the crosslinking agent, and for homogenizing the two components, was 5% by weight of MIBK.

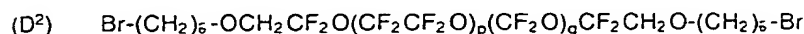
EXAMPLE 2

Into a 2 l and 2 necks flask (reflux condenser with nitrogen flask and 1 l dropping funnel) equipped with magnetic stirrer, 280 ml of 1,6 dibromohexane and 100 ml of t-butanol are loaded. A solution of 40 g of potassium t-butyrate in 700 ml of t-butanol containing 150 g of a fluoropolyether of formula:



having $p/q = 0.77$, number average molecular weight M_n 1000 and functionality 1.96, was dripped in 4 hours into the solution in the flask, kept at 80°C .

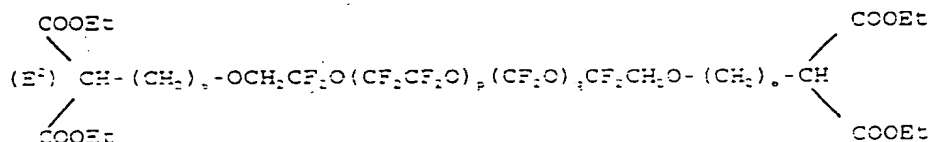
2 hours after the dripping end the pH of the solution is neutral. Then the by-product salt (KBr) is filtered and t-butanol and 1,6 dibromohexane in excess are recovered by distillation. The fluorinated oil (180 g) corresponding to the structure



is obtained as residue.

Similarly to what reported for the malonation reaction in Example 1, 100 g of the oil (D^2) are treated with 44.5 ml of ethyl malonate in a solution of 5.9 g of sodium in 300 ml of anhydrous ethanol.

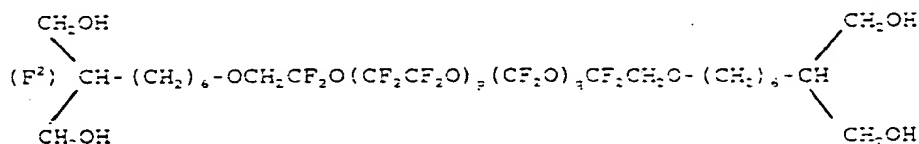
103 g of oil having the structure:



are recovered.

100 g of tetraester (E^2) are reduced with 200 ml of a 1M LiAlH_4 solution in THF further diluted with 200 ml of THF at 60°C , similarly as in Example 1.

80 g of compound of formula



having equivalent weight 388, are recovered.

The viscosity and solubility characteristics are reported in Table 1.

Crosslinking test 1

The polyol (F^2) was crosslinked in 1 hour at 90°C , 100 ppm of dibutyltindilaurate DBTDL as catalyst, with a prepolymeric crosslinking agent having an isocyanic basis, constituted by 1 mol of trimethylolpropane and 3 moles of isophoronediiisocyanate (prepolymer TMP/IPDI) in butylacetate, maintaining a NCO/OH ratio about 1.1/1. The butylacetate solvent was used in amounts equal to 10% by weight related to the formulation, made by fluorinated polymer and crosslinking agent.

The characteristics of the obtained film, homogeneous and transparent, are the following:

Adhesion to Al (ISO 2409)	100%
Hardness (Bucholtz, ISO 2815)	70
Gloss (ISO 2813, 60°)	78
Folding resistance (MU 515)	<3.17 mm
MEK Test (to check crosslinking)	>100 double strokes

Crosslinking test 2

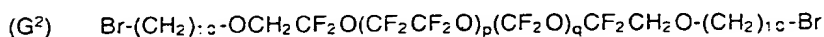
The polyol (F^2) was crosslinked under the same previous conditions with a prepolymer based on trimethylolpropane and 2,4-toluenediisocyanate (prepolymer TMP/TDI) in a solution containing 18% by weight, related to the formulation, of a solvent consisting in a mixture of butyl acetate and PMA (propyleneglycol methylether acetate).

The film looks like in the previous test and has the following properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	75
Gloss (ISO 2813)	80
Folding (MU 515)	<3.17 mm
MEK Test	>100 double strokes.

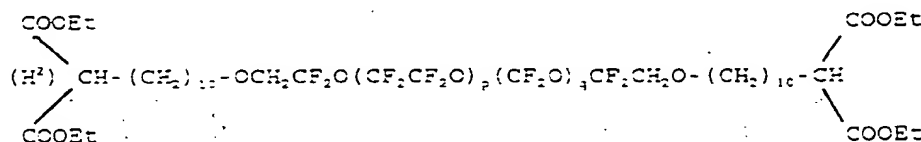
EXAMPLE 3

According to example 2, 150 g of fluoropolyether (Z^2) are treated with 450 g of 1,10 dibromodecane, 40 g of potassium t-butyrate and 800 ml of t-butanol. 185 g of adduct

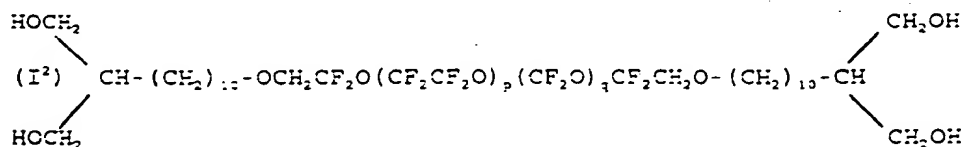


are recovered.

100 g of (G^2) are treated with 29 g of diethyl malonate, 3.85 g of sodium and 200 ml of ethanol to give 105 g of tetraester



100 g of tetraester (H^2) are at last reduced with $LiAlH_4$ /THF according to the usual modalities to give 82 g of tetraol of formula



which, titrated with phenylisocyanate, results to have an equivalent weight 358.

This polyol looks like a wax solid at room temperature (because of melting around $+30^\circ C$, evident in DSC), soluble in most of the conventional organic solvents (see Table 1) because of the hydrogenated and fluorinated mixed composition of the chain. The product is miscible both with hydrogenated polyols (for instance trimethylolpropane) and with fluorinated diols, such as perfluoropolyether having hydroxylic

terminals, from which Z² derives. In this way blends as indicated below can be obtained.

The characteristics of some films obtained by the formulations with tetraol (I²), trimethylolpropane and fluoropolyether diols type Z² are reported hereinafter.

5 Blend 1

The tetraol (I²) is mixed with the fluoropolyether diol (Z²), the ratio in hydroxylic equivalents being 1:1. It is mixed and then crosslinked with the crosslinking prepolymer TMP/IPDI (maintaining a ratio in equivalents NCO/OH of about 1.1/1), in a solution containing 15% by weight, related to the formulation, of butyl acetate containing 100 ppm of DBTL (catalyst).

The limpid solution was crosslinked at 90 °C for 60 minutes.

An homogeneous and transparent film is obtained, having the properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	60
Gloss (ISO 2813)	75
Folding (MU 515)	<3.17 mm
MEK Test	>100.

20 Blend 2

The tetraol (I²) was mixed with trimethylolpropane, the ratio in hydroxylic equivalents being 1:1. It was then treated in butyl acetate (19% by weight related to the formulation) with the crosslinking prepolymer TMP/IPDI (NCO/OH 1.1/1) and crosslinked at 90 °C for 1 hour.

A film is obtained as indicated above, having the following properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	85
Gloss (ISO 2813)	82
Folding (MU 515)	<3.17 mm
MEK Test	>100.

35 Formulation as such 1)

The tetraol (I²) was crosslinked with the prepolymer TMP/IPDI, maintaining a ratio NCO/OH 1.1/1, in a formulation containing 19% by weight of butyl acetate which contained 100 ppm of DBTL.

A film is obtained as above, having the following properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	70
Gloss (ISO 2813)	75
Folding (MU 515)	<3.17 mm
MEK Test	>100.

50 Formulation as such 2)

The tetraol (I²) was crosslinked with a prepolymer formed by 1 mole of TMP and 3 moles of 2,4-toluendiisocyanate (prepolymer TMP/TDI) with a ratio in equivalents NCO/OH 1.1/1 and in a formulation containing 19% by total weight of solvent (butyl acetate PMA mixture).

The film appears as indicated above, having the following properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	83
Gloss (ISO 2813)	84
Folding (MU 515)	<3.17 mm
MEK Test	>100.

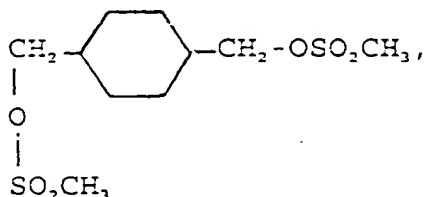
Formulation as such 3)

The tetraol (L^2) was mixed without solvent (0% by weight of solvent related to the formulation) with CYMEL^(R) 303, using a weight ratio of 8 to 2, and was crosslinked at 130 °C for 30 minutes by catalysis of p-toluensulphonic acid. The film, homogeneous and transparent, has the following properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	63
Gloss (ISO 2813)	78
Folding (MU 515)	<3.13 mm
MEK Test	>100.

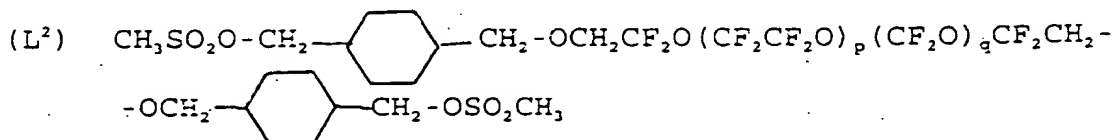
EXAMPLE 4

Similarly to the previous examples, 100 g of fluoropolyether diol of formula (Z^2) are dissolved with 34 g of potassium t-butyrate in 600 ml of t-butanol, then added to a solution of 100 g of 1,4-cyclohexanedimethanol dimesylate



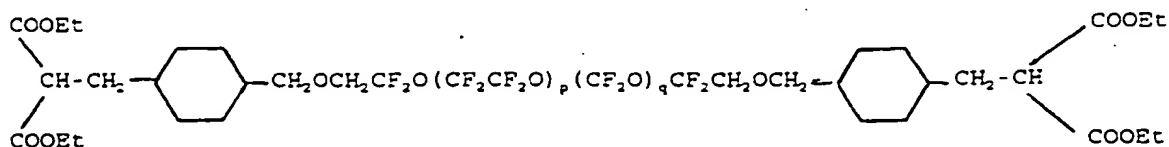
obtained according to what reported in literature (Haggis-Owen, "J. Chem Soc.", 1953, pages 404-407) dissolved in 400 ml of dioxane at 85 °C.

After cooling and filtering of the salt and of the dimesylate in excess, 105 g of compound of formula

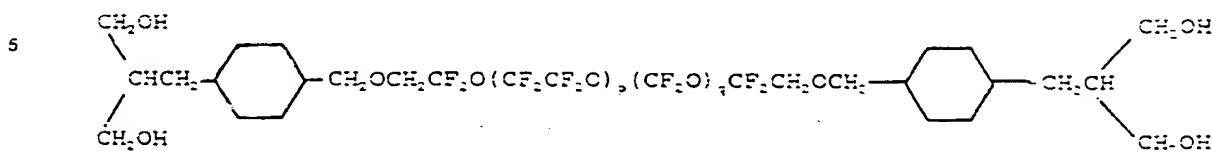


are recovered by evaporation.

100 g of dimesylate (L^2) are added to a solution of 4.25 g of sodium dissolved in 250 ml of anhydrous ethanol containing 29.1 ml of diethyl malonate to give 95 g of tetraester (M^2):



90 g of tetraester (M²) are reduced with 150 ml of a 1M LiAlH₄ solution in THF diluted with 300 ml of anhydrous THF at 55 °C, to give 82 g of oil corresponding to the structure (N²):



titrated by the phenylisocyanate method, it results to have an hydroxylic equivalent weight of 640.

The rheological and solubility characteristics are summarized in Table 1.

Crosslinking test 1

15 The tetraol (N²) was crosslinked with a prepolymer TMP/IPDI (ratio NCO/OH 1.1/1) in a formulation containing 15% by weight of butyl acetate as solvent and 100 ppm of DBDTL as catalyst, for 1 hour at 90 °C, giving an homogeneous and transparent film having the following properties:

20

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	60
Gloss (ISO 2813)	75
Folding (MU 515)	<3.17 mm
MEK Test	>100.

25

Crosslinking test 2

30 The tetraol (N₂) was mixed with the crosslinking melaminic resin in a weight ratio 8:2 (CYMEL^(R) 303, Cyanamid) and crosslinked at 130 °C for 30 minutes, with p-toluenesulphonic acid as catalyst. No solvent was used with the formulation so obtained. The characteristics of the obtained homogeneous and transparent film are reported:

35

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	63
Gloss (ISO 2813)	75
Folding (MU 515)	<3.13 mm
MEK Test	>100.

40

Crosslinking test 3

45 The tetraol (N²) was mixed with the crosslinking prepolymer TMP/TDI (NCO/OH ratio about 1.2/1) in a formulation containing 18% by weight of butyl acetate as solvent and 100 ppm of DBTDL as catalyst and crosslinked 1 hour at 90 °C, obtaining an homogeneous and transparent film.

50

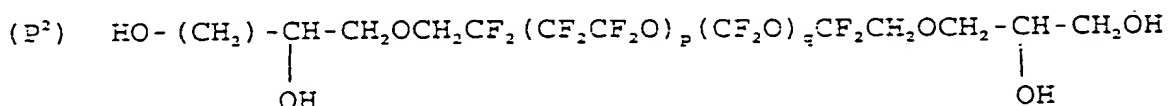
Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	70
Gloss (ISO 2813)	83
Folding (MU 515)	<3.13 mm
MEK Test	>100.

55

EXAMPLE 5

The same fluoropolyether diol (Z^2) of example 2 is mixed with the crosslinking prepolymer TMP/IPDI (NCO/OH 1.1/1) and with 20% of butyl acetate, obtaining a limpid solution. Such solution, containing 100 ppm of dibutyl tin dilaurate as catalyst, is crosslinked at 90 °C for 60 minutes, giving an homogeneous and transparent film, endowed with good adhesion to various sublayers (aluminium, glass, plastic, etc.) and high elasticity (folding resistance and elongations up to 50%).

The film hardness can be obtained from extremely low values of the Bucholtz scale up to 70-80, by admixing variable amounts, from 0 to 10%, of polyfunctional hydrogenated polyols described above, such as the polyols seen in example 3, or also tetraols of formula



The P^2 compounds are obtainable according to the usual processes of the organic chemistry, for instance the fluoropolyether diol (Z^2) salfied with potassium t-butyrate in t-butanol, is added to a solution of glycidol in t-butanol at 70 °C, and subsequently neutralized.

The rheological and solubility characteristics of P^2 are reported in Table 1.

EXAMPLE 6

Example of crosslinking of mixture Z-DOL (Z^2)/Z-TETPAOL (P^2) with blocked isocyanates.

An equiponderant mixture of $Z^2 + P^2$ (3 g) is crosslinked in 30 minutes at 150 °C with 2.8 g of the isocyanurate from the IPDI blocked with ketoxime (commercial product Huels VESTANAT^(R) B 1358) in the presence of DBTDL (0.5% w/w in respect to NCO groups) as catalyst and 20% w/w of butylacetate as solvent in the formulation.

An homogeneous and transparent film having the following properties:

Adhesion to Al (ISO 2409)	100%
Hardness (ISO 2815)	80
Gloss (ISO 2813)	78
MEK Test	>100,

is obtained.

Comparative Example**Comparative synthesis of polyurethane resin**

In a 1 l reactor 150 ml of butyl acetate, 1 mole of isophoron diisocyanate (IPDI) and then 1 mmole of dibutyltin dilaurate (DBTDL) in 5% solution (weight/weight) in butyl acetate are loaded.

The solution is heated to 70 °C and 0.5 moles of Z-DOL of formula Z^2 are dripped into it in 2 h. When the dripping is over, the solution is left at 70 °C for 2 additional hours; then the solution containing the isocyanic prepolymer so obtained is discharged into a second reactor containing 150 ml of butyl acetate and 1 mole of trimethylolpropane (TMP).

When the addition is ended, the reaction mixture is left under N_2 at 70 °C until the isocyanic groups disappear (by I.R. analysis).

A fluorinated resin having a dry content of 70% and a viscosity of 1700 cP is obtained.

10 g of the fluorinated polyurethane resin so obtained, having 70% of dry content in butyl acetate, further diluted in 8 g of a solvent mixture (PMA : butylacetate = 3:7), are mixed with 3.48 g of crosslinking polyisocyanate (product Bayer, DESMODUR^(R) N 3300), dissolved in 8 g of the above solvent mixture in order to obtain a final concentration of the solvent equal to 65%, and crosslinked at 90 °C in 1 hour.

If one works at a higher concentration of dry content, the formulation has no rheological characteristics to be used as coating.

T A B L E 1
S o l v e n t s

Ex.	Fluorinated Polymer	Hydroxylic equivalent weight	η (cP, 20°C)	$C_{1/2}$ *	η 10% **	Alcohols	Ketones, Esters	Hydrocarbons
1	A ² C ¹	630 385	144 960	4.1% 2.6%	31 123	+	+	-
2	Z ² P ²	500 388	103 3500	3.5% 2.2%	17 280	+	+	-
3	I ²	358	2370***	2.1%***	140***	+	+	±
4	N ²	640	2000	2.2%	130	+	+	-
5	P ²	300	2970	2.5%	240	+	±	-

* $C_{1/2}$ is the concentration at which the viscosity of the oil ("dry") is halved (reference solvent MIBK, temperature +20°C);

** η 10% (10% by weight of MIBK solvent) is the viscosity in cP of a solution having 90% by weight of "dry" in MIBK (T = +20°C);

*** viscosimetric tests carried out at +32°C, i.e. 2°C above the melting point of the tetraol I²;

+ means that the oil (the "dry" according to the present invention) is soluble in the class of the indicated solvents;

- means that the oil is not soluble in the class of the indicated solvents;

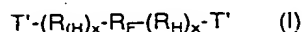
± means that the oil is partially soluble, i.e. there exist solubility gaps.

55 Claims

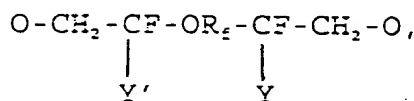
1. Use of fluorinated polymers for the preparation of high dry formulations for paints and coatings wherein the fluorinated polymers are based on fluoropolyethers comprising a fluorinated part R_F and optionally

an hydrogenated part R_H , the bonds joining the fluorinated part to the hydrogenated one being of ether C-O simple type, the terminals T' being such as to render the structure bi or polyfunctional, making thus possible the crosslinking reaction, the hydrogenated part R_H not containing groups capable of linking by means of hydrogen bonds to basic acceptors.

2. Use of fluorinated polymers according to claim 1 represented by the formula



wherein
 R_F is



wherein R_ϵ is a perfluoropolyether chain, Y and Y' being same or different from each other and being F or CF_3

x is 0 or an integer from 1 to 10,

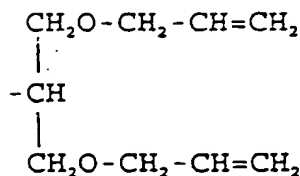
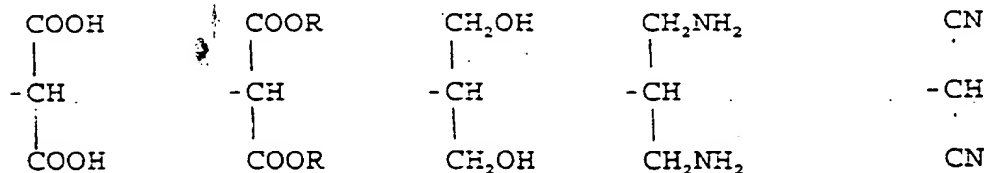
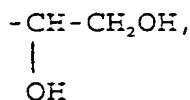
R_H is a linking bivalent radical, of linear aliphatic type $-(CH_2)_m-$, m being an integer from 1 to 20, or of (alkylene)cycloaliphatic type or of (alkylene)aromatic type, optionally having also heteroatoms, the number of carbon atoms being from 3 to 20 for the cycloaliphatic compounds and from 5 to 30 for the aromatic ones; the R_H group can be also a mixture of the indicated types;

$T' = -(CH_2CH_2O)_n-R_H)_{x'}-T$, wherein n is 0 or an integer from 1 to 6,

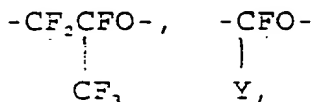
x' is 0 or an integer from 1 to 10, x' can be different from x ; and

T being hydrogen or a terminal capable of rendering bi- or polyfunctional the structure such as to make it reactive towards the crosslinking agents of both ionic and radical type.

3. Use of fluorinated polymers according to claims 1 and 2 wherein the terminals T are of the type H,



4. Use of fluorinated polymers according to claims 2 and 3 wherein R_1 represents a fluoropolyetheral chain bifunctional radical comprising as repetitive units sequences of one or more oxyfluoroalkylene units of the type



wherein R_4 and R_5 , same or different from each other, are selected from H and Cl; Y is F or CF_3 .

5. Process for preparing the fluorinated polymers of claims 1 and 2 comprising the etherification of a fluoropolyether having hydroxylic terminals by salification of the fluoropolyether and nucleophilic reaction with alkylic or arylic dihalides or pseudohalides, obtaining a fluorinated polymer A') of formula corresponding to (I) wherein T' is replaced by X, the terminal X being susceptible of further nucleophilic attack; subsequent functionalization by nucleophilic attack of A') with compounds containing carbonanions to obtain the compound (I) containing the T terminal; then, optionally, transformation of the crosslinkable functional T groups by reaction of reduction or extension of chains with polyols, or ammonolysis or hydrolysis depending on the terminal of compound I.

6. Process according to the previous claim comprising:

1° step) direct etherification of the fluoropolyether with hydroxylic terminals, by dissolution in a solution of potassium or sodium alcoholate in the corresponding alcohol obtaining the alcoholate of the fluoropolyether; subsequent reaction in solution of t-butanol or other solvent containing a large excess of alkylic or arylic dihalide or pseudohalide, the reaction temperature being comprised from $+30$ to $+90^\circ\text{C}$ and the reaction time being 1-8 hours, isolating then the alkylated fluoropolyethers by precipitation in H_2O and filtration, so obtaining the compounds of general formula (A') corresponding to the compounds of formula (I) wherein the terminal is X (instead of T), X being still a replaceable reactive terminal;

2° step) functionalization by using active methylene compounds, such as ethyl or methyl malonate or ethyl or methyl 1,1,2 ethanetricarboxylate, the reaction being carried out by slowly adding the adduct (A') to an alcoholic solution for instance of sodic or potassic malonate, at a temperature of $40-80^\circ\text{C}$ heating for 2-8 hours, obtaining the polyfunctionalized adduct I, wherein the terminal T contains COOR , wherein $\text{PFPE} = \text{R}_F$ as defined above, R_H being the alkylene residue of the halide, R being CH_2CH_3 or CH_3 of the malonate; optionally obtaining from the adduct I the release of other reactive functions, typically by reduction of the carboxylic esters for instance with $\text{LiAlH}_4/\text{THF}$.

7. "High dry" formulations for paints comprising the fluorinated polymers of claims from 1 to 4, and a solvent, in amounts of 20% by weight at most, selected from the classes of those used for preparing paints, excluding the fluorinated solvents not containing hydrogen; the weight percentage of the solvent being referred to the ratio between solvent weight and formulation weight, the formulation being the whole of the non volatile components plus solvent mixture.

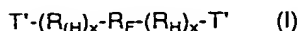
8. Formulations according to claim 7 wherein the solvent is less than 10% by weight.

9. Formulations according to claims 7 and 8 wherein the solvent is selected from the classes of ketones and acetates.

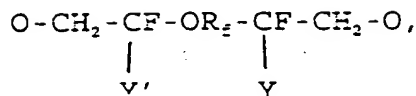
10. Formulations according to claims 7 and 9 wherein a bi or polyfunctional hydrogenated polyol is added in equivalents ratio of hydrogenated polyol to fluorinated polymer from 0.1 to 5.

11. Coatings and films obtainable from the formulations of claims 7-10 by crosslinking of the fluorinated polymers and evaporation of the solvent.

12. Fluorinated polymers according to claim 1 represented by the formula



wherein
R_F is



wherein R_F is a perfluoropolyether chain, Y and Y' being same or different from each other and being F or CF₃

x is 0 or an integer from 1 to 10,

R_H is a linking bivalent radical, of linear aliphatic type -(CH₂)_m-, m being an integer from 1 to 20, or of (alkylene)cycloaliphatic type or of (alkylene)aromatic type, optionally having also heteroatoms, the number of carbon atoms being from 3 to 20 for the cycloaliphatic compounds and from 5 to 30 for the aromatic ones; the R_H group can be also a mixture of the indicated types;

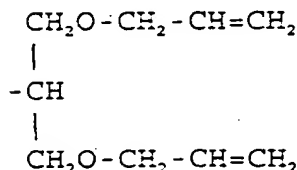
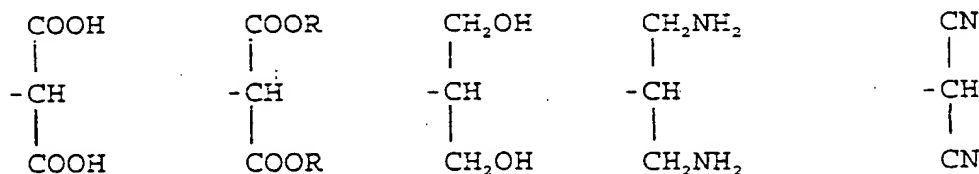
T' = -(CH₂CH₂O)_n-R_H-T, wherein n is 0 or an integer from 1 to 6,

x' is 0 or an integer from 1 to 10, x' can be different from x; and

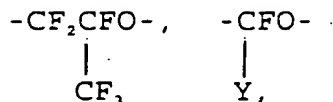
T being hydrogen or a terminal capable of rendering bi- or polyfunctional the structure such as to make it reactive towards the crosslinking agents of both ionic and radical type;

excluding T' = H, -CH(OH)-CH₂OH when n = 0 and x' = 0.

13. Polymers according to claim 12 wherein the terminals T are of the type H, -CH(OH)-CH₂OH,



14. Polymers according to claims 12 and 13 wherein R_F represents a fluoropolyether chain bifunctional radical comprising as repetitive units sequences of one or more oxyfluoroalkylene units of the type
-CF₂CF₂O-, -CR₄R₅CF₂CF₂O-,



wherein R₄ and R₅, same or different from each other, are selected from H and Cl; Y is F or CF₃.



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 95 10 1145

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	DE-B-20 66 042 (MINNESOTA MINING AND MANUFACTURING CO.) * claim 1 * * structure 6 * * page 4 *	1-13	C08G65/00 C09D171/02 C08G65/32
A	EP-A-0 548 745 (AUSIMONT S.P.A.) * claims 1-7 *	1-14	
A	EP-A-0 098 699 (MINNESOTA MINING AND MANUFACTURING CO.) * claims 1,6,7,9,10 *	1-14	
A	EP-A-0 533 159 (SYREMONT S.P.A.) * claims 1-3 * * page 5, line 5 - line 11 *	1-14	
A	DATABASE WPI Derwent Publications Ltd., London, GB; AN 87-286808(41) & JP-A-62 161 743 (NIPPON OIL SEAL IND) 17 July 1987 * abstract *	1,5,6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C08G C09D
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		16 May 1995	O'Sullivan, T
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